3703

THE SCIENCE OF MEAT AND MEAT PRODUCTS

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young, growing chickens. With diets containing around 10% or more of added fat, feed conversions of 2.0 lb or less of feed per pound of gain are commonly obtained.

The conversion of feed by hogs and beef cattle has not yet reached the high state of efficiency that has been achieved in poultry, but recent advances have been made in that direction. Swine that are fed rations with added fat often show an increased growth rate as well as improved feed conversion. Cattle and sheep present a somewhat different picture because the ruminant is less dependent upon concentrated sources of energy. However, cattle can utilize up to about 1 lb per head per day of fat, and improved rates of gain with improved feed conversions have been reported (Hale *et al.*, 1965).

It is recognized that considerable variation in composition of protein by-product feeds exists between processing plants and from day to day within a plant because of nonuniformity of raw materials. However, such variations are less today than they were earlier. Blending of raw materials or of the finished product and increased control of rendering times and temperatures, particularly in plants that have installed continuous systems, have undoubtedly been the major factors in this improvement. Still, much research remains to be done in order to utilize these products and animal fats to their fullest extent in feeds or for other industrial purposes.

HIDES, SKINS, AND NATURAL CASINGS

J. Naghski

Throughout human history animal skins have been closely associated with man's way of life. Primitive and nomadic people used them and still use them for shelter and clothing, for weapons, and for carrying food and water. The art of tanning appeared very early in history, but even today much of its science awaits elucidation. In more recent times the harness trade consumed a major portion of the supply of domestic hides until the automobile eliminated the beast of burden as a major means of transportation. The really damaging blow to the hide and leather market has been dealt by the low-cost production of vast quantities of synthetic materials which are widely used in place of leather.

The superior moisture vapor transfer and insulating properties of the fibrous network in leather have maintained the market for shoe upper leather as well as for soles of the better quality shoes. New techniques are providing fine leather garments, but these are in the luxury class and utilize only perfect or near-perfect skins. With gelatin, glue, and fertilizer taking only a minor portion of the market, the industry urgently needs new uses and markets for hides and leather.

Intestines that are utilized as casings represent a portion of the meat animal whose principal value lies in this traditional use. Absorbable surgical sutures, musical instrument strings, and tennis racket strings also are markets for intestines, each use demanding a particular kind or selection of casing. Animal casing, after processing, is particularly well adapted for some processed foods and competes successfully with artificial casings. With mass produced items (e.g., frankfurters and bologna) where uniform size is desired, cellulosic casings have largely displaced their natural predecessors. On the other hand, natural casings obtained not only from small intestines but also from stomachs, bladders, and sewed casings are popular for specialty meat items; sewed casings provide some of the uniform size characteristics that are available with artificial casings. Domestic production provides satisfactory quantities of hog and beef casings but not enough sheep casings. This shortage is due to the small number of mature animals marketed and to the intestinal parasites found in sheep in North America. Consequently, the majority of sheep casings used are imported and are already processed and preserved.

Histology of Skin

The skin is composed of three major layers: the surface, pigmented epidermis; the underlying connective tissue, the corium; and the subcutis, which provides the attachment to the underlying organs. Within these layers are many additionally identified groupings. The thickness of the skin varies between animal species and within one species with age, sex, and region of body. It is reported to be thicker on the back and on the exterior surfaces of the limbs than on the ventral and flexor surfaces.

Epidermis

The comparatively thin epidermis extends downward from the surface as a tubular invagination and forms a part of the hair follicle. The connective tissue papilla is formed at the base and projects into the follicle. From this the hair shaft is formed and projected to the surface.

Corium

Associated with the hair follicles and embedded in the upper section of the corium are the sebaceous glands, the erectile follicular muscles (smooth), and many elastin fibers interwoven with fine reticulin and collagenous fibers. The deeper portion of the corium consists predominantly of large bundles of collagen interwoven in many directions. In animals such as the ox, the distance from the epidermal surface to the hair root constitutes only about one-third of the total depth of the skin. In the pig, however, the hair follicle

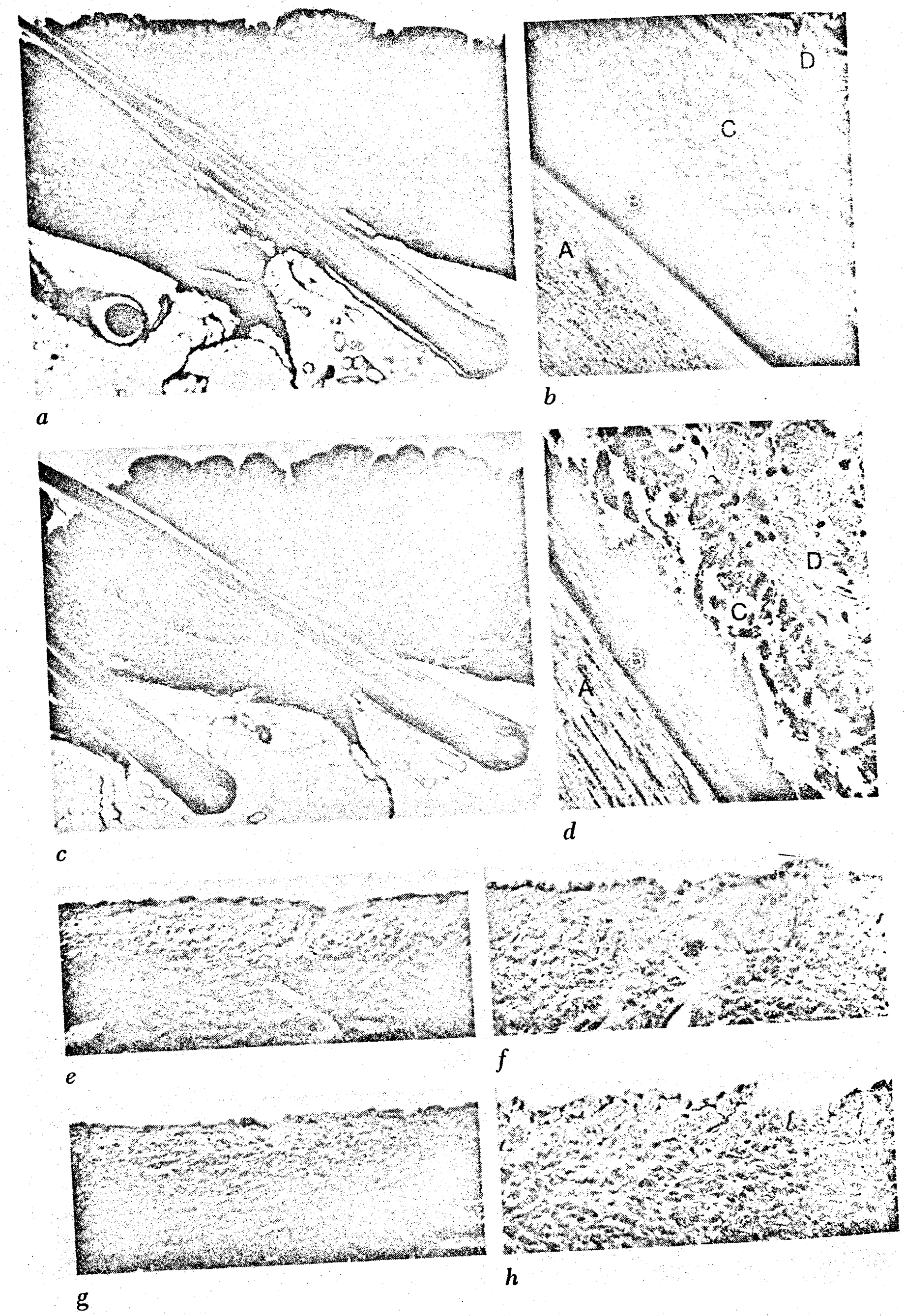


FIGURE 13–5.

(*a*) Vertical section of normal hogskin, × 21. See Figure 13–4 for identification of structures.
(*b*) Magnified longitudinal portion of normal hair shaft (A) and adjacent tissue; inner hair sheath (B); outer hair sheath (C); and corium (D), × 330.

By scalding hogs at proper temperatures and for specific lengths of time (Wang, 1954) the continuity between the hair sheaths and their adjoining structures can be disrupted (see Figs. 13–5*c* and 13–5*d*). Hair and epidermis removal are thus facilitated without excessive damage to the valuable corium.

For comparative photomicrographs of raw hides of many species, normal and excessive effects of leather processing, and abnormal conditions produced by infestations and diseases, the reader is referred to the publication of the British Leather Manufacturer's Research Association listed in the references.

Classification of Hides and Skins

Bovine Hides and Skins

A skin is a small hide which, in the case of cattle, weighs under 30 lb after curing. Many factors are involved in classifying a hide; among them are weight of the hide, sex and maturity of the animal, existence and location of brands, method of preservation or curing, and size and location of the slaughtering agency. Table 13–15 lists the categories in which hides are marketed based on net weights after manure and tare allowance are deducted.

Brands and their locations affect the value of a hide, since they represent scar tissue in a premium value area. Hides branded on the butt or side are known as *Colorados* or *Texas hides*, the latter being plump and close-grained. Unbranded hides are known as *natives*.

When hides were taken off by relatively unskilled labor, e.g., by some country butchers or in some small packing plants, they were damaged more frequently than hides taken off in large packing plants. The latter, called *big-packer hides*, were also of more uniform classification and commanded a better price than the former, which were called *country* or *small-packer hides*. However, in recent years, many small packers have adopted improved production and grading practices and their hides no longer deserve the *small-packer* classification. This has led to the adoption of the term *standard packer hides* as a distinction from *country* and *locker plant hides*. A small percentage of domestic hides are taken off animals that die from some other cause than slaughter. These are called *renderer* or *murrain* hides.

(*c*) Vertical section of properly scalded hogskin. Compare with (*a*) for separation of tissues around hair and change in appearance of epidermis, × 24.

(*d*) Magnified longitudinal portion of scalded hogskin. Note separation of outer hair sheath (C) as compared with that shown in (*b*), × 330.

(*e*) Hogskin dehaired and normally singed, × 20. Compare with (*f*).

(*f*) Hogskin dehaired and excessively singed. Note markedly damaged grain layer, × 20.

(*g*) Grain damage produced by normal shaving, × 22. Compare with (*h*).

(*h*) Grain damage produced by excessive shaving, × 22.

TABLE 13-15
Classification of cattle hides

Origin	Weight (lb)	Designation
Unborn calf		Slunk skin
Calf	Less than 9	Light calfskin
	9–15	Heavy calfskin
	15–25	Kipskin
	25–30	Overweight kipskin
Cow	30–53	Light cowhide
	Greater than 53	Heavy cowhide
Steer (male, castrated as a calf)	Less than 48	Ex-light steerhide
	48–58	Light steerhide
	Greater than 58	Heavy steerhide
Bull (mature male, uncastrated)	60–100+	Bullhide
Stag (mature male, castrated)		Accepted as steer or bullhide depending upon characteristics

Pigskins

Slaughterhouse practice in the United States calls for leaving the skin of the hog on the carcass. Hence, most pigskins available from the domestic market are strips taken from the lard area of the back. These skins are used primarily for gelatin rather than leather. Recently a machine was developed that was capable of removing the skin from the pigside in the area between the shoulder and ham cuts. This system provided the tanner with a useful piece of skin and has led to the successful development of a sueded pigskin upper shoe leather. Almost all of the whole pigskins tanned in this country are imported.

Sheepskins

Since the major value of sheepskins is represented by the wool, most of the skins are dewooled at the wool pulleries, then preserved or pickled with dilute sulfuric acid and salt. Imported skins may be pickled, salted, or dried, and some still have their wool.

The major classifications of sheepskins or *pelts* are based on the length of the wool. Table 13-16 shows these classifications.

TABLE 13-16
Classification of sheep pelts

Classification	Grades	Wool length (in.)
Shearlings	1	$\frac{1}{2}$ and including 1
Shearlings	2	$\frac{1}{4}$ and including $\frac{1}{2}$
Shearlings	3	$\frac{1}{8}$ and including $\frac{1}{4}$
Shearlings	4	$\frac{1}{8}$
Fall clips		1 and including $1\frac{1}{2}$
Wool pelts		$1\frac{1}{2}$

Other Hides and Skins

Hides and skins of the horse, goat, hair sheep, India buffalo, kangaroo, and wallaby are important to certain specialists in the tanning industry but are not involved in the modern packing industry of the United States.

Packinghouse Procedures

Bovine Hides and Skins

FLAYING. *Flaying* is the special term used to describe the skinning operation performed by skilled workmen following a uniform pattern. It is essential to a profitable operation that the hide or skin be removed with a minimum number of cuts or scores. Relatively minor cuts in the flesh side of a hide have a pronounced weakening effect upon the leather made from it. A flaw can be seen on the grain surface of a heavy piece of sole leather even after tanning and final finishing, and the wearing quality of the leather is reduced. Consequently, such hides are downgraded when sold. Of perhaps even greater importance to the meat industry is separating a minimum of flesh from the carcass during flaying. When flesh is left on the carcass, it is in the edible class and commands a corresponding price. Flesh left on the hide interferes with curing or preservation of the hide, and if removed from the hide it must go to inedible rendering.

TRIMMING. A hide has a number of components, such as ears, snouts, dew claws, tail, and other appendages that do not make leather or interfere with proper tannery processing. The packing and tanning industries have arrived at definitions of trim that are now accepted as standards. Although the hide trim results in a higher price per pound to the tanner, there is an economic gain in saving of freight, labor for trimming and cost of disposing the offal. The packer gains more offal for his rendering operation.

PRESERVATION. In this country, hides are preserved either by curing with solid salt, with brine, or a combination of the two. The process of curing with salt is called *green salting* or *salt-pack curing*. The process consists of first cooling the hide until respiration of the tissue diminishes, then spreading salt over the flesh side and building a pack of skins in much the same fashion as shingles are placed on a roof. Fine salt is needed for the more delicate calfskins while with kip weights and mature hides a coarser rock salt is used.

Thirty days is the accepted time required to saturate the hide tissues with salt, after which they are individually shaken out and spread flesh side up for inspection and grading. Each hide is then folded in a prescribed way into a bundle, and the bundle is weighed and stacked for shipment.

The process of salt curing is dynamic, i.e., it is not simply a process of saturating, for there is a net decrease in weight of approximately 15–20%, which is due primarily to water loss. Migrating toward the interhide brine, formed in the pack, are water-soluble substances including albumins and globulins, peptides, amino acids, carbohydrates, and other minor constituents. These substances may be expected to localize near the surface of the hide as they are salted out when they encounter the higher salt concentrations.

The process of *brine curing* has evolved from the method used by large packers in South America where the fresh hides are washed and then submerged in vats of saturated brine. Salt is added to maintain saturation, and the hides are periodically poled by hand from top to bottom. After overnight soaking, the hides are drained and packed in much the same manner as in green salting. The hides so produced are of high quality.

The brine-curing process has been modified in this country by the provision of an oval tank equipped with paddle wheels to keep the hides moving and by keeping the brine at saturation by pumping it through a bed of rock salt. Additional mechanization in handling reduces the amount of hand labor to an economic level of operation.

Further modifications of brine curing have been introduced. An effective one has been termed *pit brining*. In this process hides are layered with salt in large pits to within ten inches of the four-foot depth. The top hides are covered with burlap and the pit completely filled with saturated brine containing a disinfectant. Fleshed hides are normally retained in the brine for forty-eight hours while unfleshed hides may require two weeks.

The advent of a machine for fleshing and demanuring of fresh hides has had a considerable impact upon the hide processing industry. The fleshing and accompanying trimming operations result in an approximately 22% decrease in the weight of the hide from what it would be under conventional curing. Such precuring operations provide for more efficient penetration of curing ingredients and suggest the possible use of newer preservatives (alone or in combination with salt), which could reduce the occasional spoilage losses that occur today.

The complex nature of the fleshing and demanuring machine makes it quite costly and necessitates the processing of at least 500 hides daily for its economic use (Biedermann *et al.*, 1962). As a consequence hide processors increase their volume of production by procuring hides from a number of abbatoirs and transporting them to a central processing plant. The perishable nature of hides restricts the distance over which fresh hides can be safely transported, and it is not surprising that cases of delayed cure have occurred.

Pretreatment of hides with such chemicals as quarternary ammonium chloride, zinc chloride, pentachlorphenate, boric acid, and others makes it possible to delay curing by a day or more. There is some question whether the cost of pretreatment can be offset by the advantages of extending the time that hides can be in transit before curing is started. A novel development being explored by packers, hide processors, and tanners is the use of a concrete mixer. Such a device would permit the curing of the hides during transit from small abbatoirs to the hide processing plant; or the unhairing process can be started during transit to the tannery.

UNHAIRING. As competition for the leather market by plastics and other substitutes becomes greater, it may become necessary for the meat packing industry to introduce more economic procedures for handling hides. It may be necessary not only to remove flesh and manure but also the hair. Currently a number of packers, hide processors, and tanners are exploring the possibility of unhairing fresh hides at the source. The concept is based on the idea that fresh hides can be prepared for tanning by being processed immediately through soaking, fleshing, liming, unhairing, and pickling. The resulting product is called *pickled hides.*

Unhairing hides at the source would benefit the tanner from savings in shipping costs, a decrease in the problem of beamhouse effluent, better grading of hides for his product needs, and a speeding up of processing. On the other hand, the hide processor would save the costs of the curing operation but would incur the increased technical problems of unhairing and pickling. Pickling is an accepted means for preserving depilated sheepskins; however, its application to the preservation of cattlehides is novel, and standards acceptable to the industry have not been established.

Pigskins

SCALDING AND DEHAIRING. Immediately after the animal is slaughtered and washed with cold water, the entire carcass is immersed in a scalding tank. The length of immersion and the water temperature have been shown to be critical factors in providing easy removal of hair without damage to the leather-making qualities of the skins. Following scalding, the carcasses are passed through a dehairing machine consisting of continuous belts equipped with metal scrapers which remove most of the hair. Before the carcass is opened it may be singed to remove residual hair. Some operators follow this with a polishing operation in which large brushes, together with a water spray, remove clinging hair. In still other cases a resin and oil mixture is painted upon the carcass prior to the polishing and is helpful in removing hair from irregular surfaces (e.g., the head).

PRESERVATION. The method of preservation of hogskins depends upon their ultimate use. Since the method of handling permits their use for edible gelatin, the strips from fatbacks are promptly fleshed, frozen into blocks, and shipped to the gelatin plants. Skins to be used for leather are cured in much the same manner as are calfskins.

Sheepskins

REMOVAL OF PELT. Sheep pelts are particularly susceptible to damage by rough handling and require skill in their removal. The process is described in detail in the book *By-Products of the Meat Packing Industry* (1950). Where wool pulleries are not operated, the skins must be spread singly and allowed to cool; they are then salted and packed prior to shipping. The preservation of sheepskins is one of the most trouble-fraught operations faced by the packer.

WASHING AND WRINGING. Fresh pelts are placed directly in cold water vats and carefully agitated to avoid grain damage. Salted skins are soaked for a long period to remove the salt, and dried skins must be thoroughly softened before agitation is begun. Excess water is removed in a centrifugal wringer.

PAINTING AND PULLING. Before the wool can be removed from the skin, its attachment must be loosened without damage to the fiber. This is usually accomplished by painting the flesh side with a paste containing sodium sulfide and lime. These reagents degrade the keratins of the epidermis and wool roots, thereby loosening the wool. After the painted pelts have hung overnight to twenty-four hours, depending on the temperature, they are placed flesh down on a beam. Since the quality of the wool varies with the location on the pelt, the puller sorts and grades the wool as it is removed. Skin-to-skin variation is too great to permit efficient pulling by machines.

TRIMMING AND LIMING. After the wool has been pulled, the skins are trimmed to remove the head, shanks, and udders. Since not all of the wool is removed by the pullers, the remainder is dissolved by paddling or drumming in a solution of alkaline sulfide for a short time. Then the sulfide solution is reduced and liming continued for a total of about twenty-four hours. At the end of the liming period the excess lime is removed with fresh running water.

DRENCHING OR BATING. After a hide has undergone the above processes, there still remain proteinaceous substances capable of supporting putrefaction and not contributing to the final leather product. Ammonium salts are employed to reduce the pH and to provide a favorable medium for the action of pancreatic proteases. The enzymes are added and permitted to digest the extraneous proteins, and the products of their action are removed by thorough washing.

PICKLING. The skins are preserved by immersion in salt solution containing 1–2% sulfuric acid. They are then drained and graded.

Tannery Procedures

Most of the output of hides and skins by the packing industry goes into some form of leather. This section will present a simplified version of the sequence of events which bring about the conversion of cured hides to leather. A fuller treatment of this important subject may be found in the works of Gustavson (1956), O'Flaherty *et al.* (1956, 1958, 1961, 1965), and Thorstensen (1969).

Beamhouse Operations

Before hides are subjected to tanning operations, they undergo considerable processing to remove nonleather-forming substances. Formerly, in such operations as trimming, removing the flesh, and removing hair and epidermis the skin was spread over a broad, oval wooden beam in front of the worker. The workers, using knives designed for the particular job, fleshed the hides and then scraped away the hair and epidermis after appropriate chemical treatment of the hides. The overall treatments are described briefly below. Although this hand labor has been replaced by machines, the tannery area in which these operations are performed is still called the beamhouse.

The cleaning operation of washing, soaking, and fleshing may require several days in order to condition the hides for later operations. Proper *washing* is no small part of the art of leather making; agitation by paddling and proper temperatures are necessary for the sake of thoroughness; yet excessive treatment results in poor grain in the final product. Washing accomplishes the following: (1) manure and urine are removed; (2) remaining soluble constituents, including proteins salted out by the curing salt, are largely removed; and (3) hide fibers are fully hydrated to protect against local caustic effects of reagents used later. Since washing reduces the salt content of the hides, it is advisable to add disinfectants to the soak waters in order to reduce the possibility of bacterial damage.

Although *fleshing* is sometimes deferred until after liming, it is customary to remove extraneous flesh from certain heavy hides after *soaking* has softened the hide sufficiently for machine handling. Removal of the adhering adipose or fatty tissue by the fleshing machine is essential to the penetration of reagents, which diffuse primarily from the flesh side, the grain surface presenting a much less penetrable barrier. Fleshing further reduces the formation of insoluble calcium soaps during subsequent liming. The use of prefleshed, brine-cured hides reduces much of the effort involved in these tannery steps, and the adoption of modern washers has decreased the time required to a matter of minutes.

The unhairing of hides and skins can be accomplished by a number of differing principles related to the chemistry of hair and keratin tissues. Hides have been unhaired by means of enzymes, oxidizing agents (chlorine dioxide), and alkalis. The most common is the use of an alkaline medium together with accelerators. The role of the accelerator *sharpeners* is to hasten the alkaline cleavage of the -s-s- linkage in keratin through a mechanism of nucleophilic displacement (Windus and Showell, 1968). Of the possible alkaline reagents, calcium hydroxide is most commonly used. Its limited solubility results in a solution of pH near 12.5. The actual pH can be controlled within slight limits by the choice and the amount of accelerator added. This latitude makes it possible to conduct unhairing under conditions that will permit destruction or saving of the hair. These conditions can be met by the judicious use of sodium sulfide or sodium sulfhydrate as the accelerator.

The principal effects of alkali upon collagen are the gradual hydrolysis of amide linkages and the swelling action typical of polyelectrolytes at pH extremes, in which ionization of basic groups of proteins is depressed but that of acid groups is virtually complete. Excessive swelling can distort the grain and impair the appearance of the finished leather. Therefore the alkalinity of liming solutions must be controlled to give a degree of swelling that can be tolerated by the type of leather to be produced.

After the above operations, the remaining soluble proteins, including the newly solubilized keratins, are subjected to the action of proteolytic enzymes as a final step preceding tanning. This is called *bating*. The enzymes of pancreatic or microbial origins are selected for a broad spectrum of activity but have no significant effect upon the tissue collagen. In order to provide a proper pH environment for the enzyme, some deliming agent such as ammonium sulfate or an organic acid is added either with the enzyme or prior to it. Then the bated hides are washed and placed directly into the vegetable yard—if destined for vegetable-tanned leather—or pickled in salt and acid—if they are to be chrome-tanned.

Tanning

The chemistry of tanning is much too complex for discussion in this limited space, and the reader is referred to the excellent monograph by Gustavson (1956), the volumes edited by O'Flaherty *et al.* (1956, 1958, 1961, 1965), and the book by Thorstensen (1969).

Again science and art are closely allied in providing the treatment prescribed for the final use of the item. Heavy leathers, such as sole, harness, bag, and case, are tanned in countercurrent systems that use extracts from tannin-bearing woods, barks, leaves, and fruits (Humphreys and Jones, 1966). The main sources are quebracho, chestnut, and wattle.

The bulk of animal hides and skins are tanned for use in shoe uppers. Such leathers are based on tanning with basic salts of polyvalent metals. Of these, basic chrome sulfate is by far the most common. Leathers with specific properties are produced by retanning chrome-tanned leather with other mineral tannages, vegetable tannins, syntans, resins, or aldehydes (Windus, 1967).

Finishing

After tanning, leathers undergo a number of operations to establish their final characteristics. These include such processes as lubrication, filling, dyeing, drying, mechanical flexing, impregnation, surface coating, embossing, and polishing.

Gelatin and Glue Manufacture

The principal sources of gelatin are calfskin trimmings, strips of porkskins, and fresh large bone called packer bone.

Glue is manufactured from almost all collagen-rich substances not made into finished leather or gelatin. These may even include leather scrap, tendons, bone stock, horn piths, fleshings, and trimmings from pickled sheepskins.

Processing for Gelatin

Gelatin is not made from calfskins until they have been thoroughly limed and washed to remove extraneous materials. Skins are then extracted initially at temperatures of 54°C to 60°C (129°F to 140°F), with successive extractions being performed at increasing temperatures up to the boiling point of water. The extracts obtained at low temperatures are the least degraded and are of higher quality.

The extractions are subsequently filtered and concentrated in a vacuum evaporator. Drying temperatures must be kept at a low level to avoid further hydrolysis until the later stages of drying, at which time the temperature is increased. The final dry product is ground and packaged.

Liming is unnecessary for porkskins, but they must be carefully fleshed to remove excess fat. In further contrast with calfskin, porkskins are extracted in an acid medium and usually at a lower temperature. The product obtained is higher in molecular weight and consequently has better gel properties. This is interesting in view of the fact that the conversion of collagen to gelatin primarily is regarded as the dissociation of a triple helix type of protein to three peptide chains or some intermediate stage.

The production of bone gelatin involves removal of fats, demineralization by acid, and extraction with dilute alkali. Cooking is performed in steam kettles at elevated pressures. Several variations in these sequences are employed commercially.

Processing for Glue

Glue stocks of various origins receive appropriate treatments to remove extraneous materials and establish a final pH near neutrality. Hide stocks are extracted in steam-jacketed kettles with successive extractions at increasing temperatures, the first extracts providing the best quality glues.

Bone stocks are, of course, demineralized with acid, washed, and crushed. The practice of pressure cooking at 10–50 lb psi produces a correspondingly smaller average molecular weight product of lower gel strength. The glues are customarily dried and ground after concentration of extracts.

Natural Casings

Because the intestinal tract and the structural pattern of its various divisions are very similar in cattle and in hogs, the anatomical and corresponding industrial terms for both beef and pork casings are illustrated in Figure 13–6. The entire intestinal tract, although it varies in diameter and wall thickness, has a similar tissue architecture throughout its length. As illustrated in Figure 13–7, there are five distinct layers of tissues:

The *mucosa* (A) surrounds the intestinal lumen and consists of: (1) the mucosal membrane, composed entirely of epithelial cells, many of which are specialized into glands, which perform functions of secretion, digestion, and absorption; (2) muscularis mucosae, which are strands of smooth muscle cells, usually arranged longitudinally, and which are not continuously present throughout the entire tract; (3) lamina propria, comprising a meager amount of connective tissue cells and fibers closely associated with the smooth muscle cells; (4) lymphatic tissue, present near the basal portion of the mucosa in the form of nodules; and (5) a small number of blood vessels and nerve plexuses.

The *submucosa* (B) consists mainly of collagenous and elastic fibers (preponderantly collagenous). Blood vessels and adipose tissue are frequently embedded in it.

The *circular muscle layer* (C) contains smooth muscle cells arranged with their longer axes around the digestive tube. In contrast to the striated muscle cells previously described, these smooth muscle cells are spindle-shaped, uninucleate, comparatively short, and devoid of bandings. They are supported by a

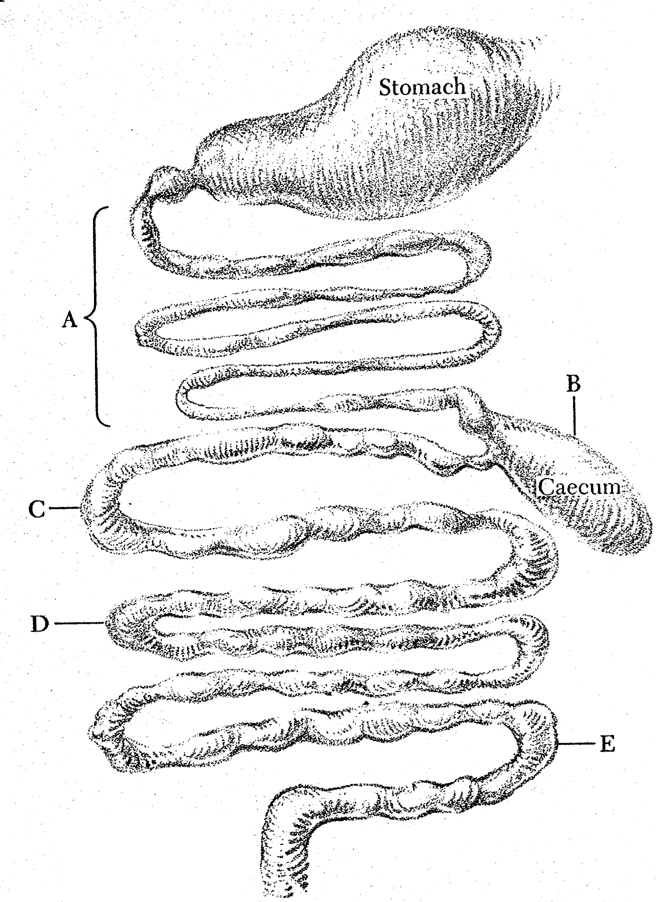
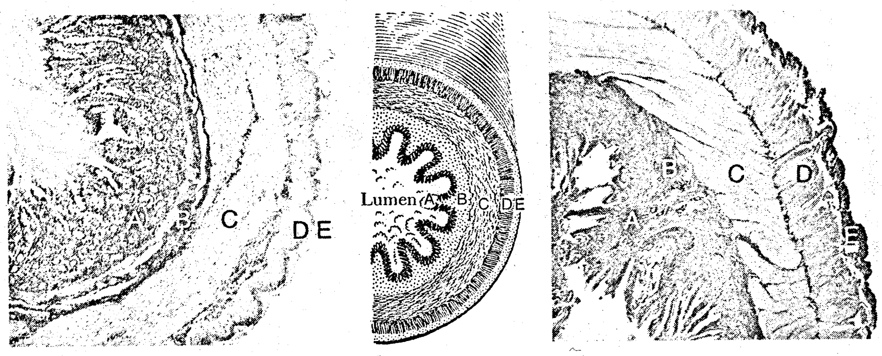


FIGURE 13–6.
Diagram of intestinal tract showing the sources of different natural casings.

Sources	Beef casings	Pork casings
A. Small intestine	Rounds	Rounds or small casings
B. Caecum	Bung	Cap
C. First portion of large intestine	Narrow-end middle	Not utilized
D. Middle portion of large intestine	Wide-end middle	Middles
E. Terminal end of large intestine	Fat-end middle	Bung



a *b* *c*

FIGURE 13–7.

Small intestine. (*a*) A transverse sector of fresh hog small intestine showing its normal structure: (A) mucosa, (B) submucosa, (C) circular muscles, (D) longitudinal muscles, and (E) serosa. Note rich content of collagenous fibers and very little fat in the submucosa. The layer of circular muscles is much thicker than the longitudinal muscles, and the serosa is very thin, × 63. (Wang, 1955.) (*b*) Schematic drawing for identification of layers. (*c*) Beef small intestine near the stomach end (lumen side on the left). The mucosa (A) is thick and folded; the submucosa (B) shows a number of small blood vessels and nerves in a triangular area joining the center of two mucous folds. Farther beneath are the circular (C) and longitudinal (D) layers of smooth muscles. They appear very prominent, with a considerable amount of collagenous fibers (dark) running through both layers, and a line of nerve plexus (small circles or dots) clearly demarcating the boundary line between these two layers. On the outside lies the serosa (E), which is dark-stained due to its large content of collagenous fibers. Fat is practically absent in this sample, × 25. (Wang, 1954.)

reticulum of collagenous fibers, which make further connections with the collagenous fibers of the submucosa and those of the layer of the longitudinal muscles. In hog intestine this layer is noticeably thicker than the longitudinal layer. This difference prevails but is less noticeable in cattle intestine.

The *longitudinal muscle layer* (D), with the cells oriented at right angles to those of the circular layer, has a high content of collagenous fibers. The two layers of smooth muscle are compositely known as the *muscularis externa.* Together they function in the peristaltic movement of the intestine.

The *serosa* (E), or external layer, of the intestine is a thin layer, as compared to the previous four, and is composed primarily of collagenous and elastic fibers and loose connective tissue cells. The serosa in hog intestine is thinner than in cattle, and is much less tightly bound to the adjacent layer.

Source: Intestinal Tissues

The difference in good quality pork and beef "rounds" after sliming is clearly shown in Figure 13–8. The more homogeneous pork round is characteristically composed of only the submucosa layer and is essentially pure col-

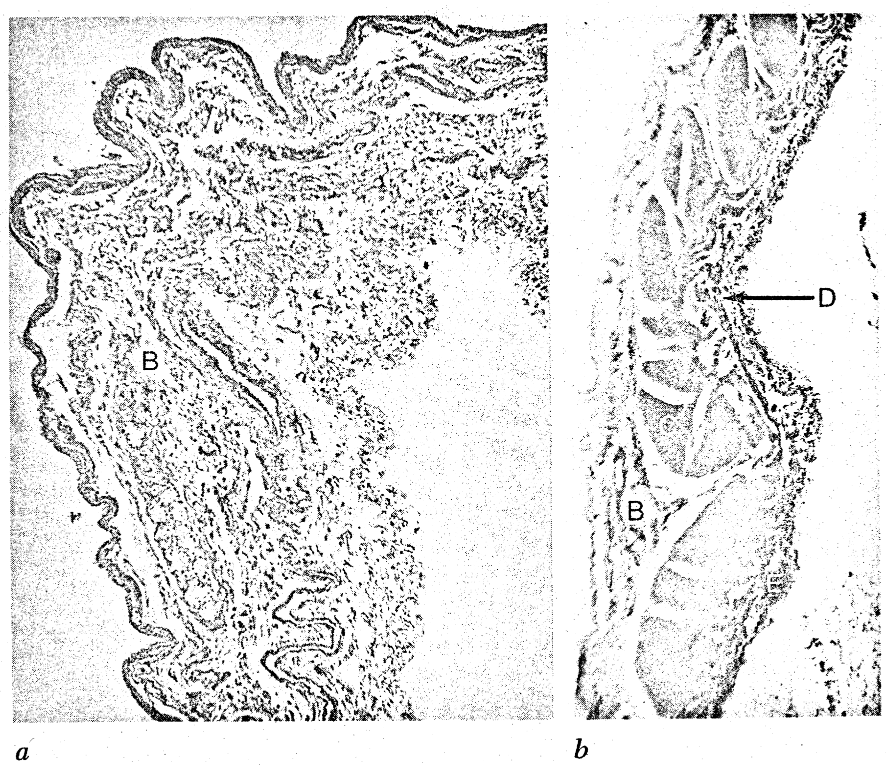
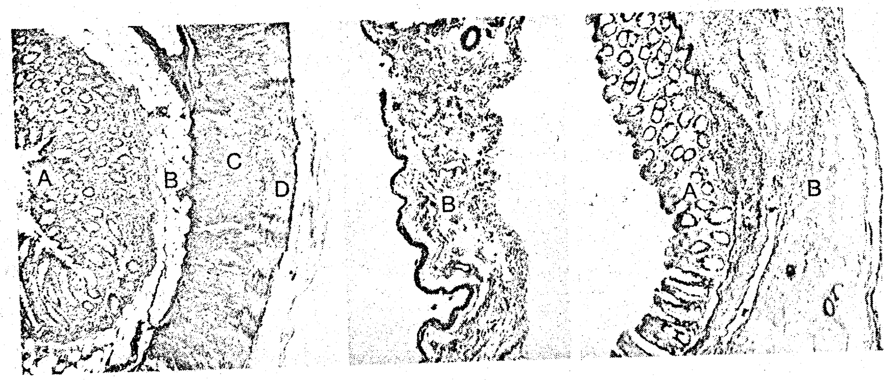


FIGURE 13–8.

Comparison of pork and beef casings. (*a*) Round, small casing derived after sliming from such (hog) structure as that shown in Figure 13–7*a*. The casing is characteristically composed of submucosa tissues (B), mostly collagenous fibers; the remaining layers, mucosa, the two muscle layers, and serosa, have been completely removed during the sliming operation. The casing is of good quality, chiefly because of its structural homogeneity, × 75. (Wang, 1955.) (*b*) Casing derived from the (beef) sample shown in Figure 13–7*c*. It is an example of good "Export Round," consisting mostly of submucosa collagenous fibers (B) on the left, two layers of smooth muscles (C, D) in the center, and serosa collagenous fibers (E). No fat or any other of the miscellaneous nonessential tissues are present, × 25. (Wang, 1954.)

lagenous fibers. Beef rounds contain the submucosa, both the circular and longitudinal muscle layers, and the serosa. A difference in the degree of binding and interlacing of the collagenous fibers in hog intestine and in beef intestine may be the real cause of the difference in results achieved by the two sliming operations. The presence of smooth muscle tissue in the beef casing is believed to inhibit the adaptability of the collagenous component.

For highest yield and quality of casings it is necessary to cleanse thoroughly the viscera of fat, nerves, blood vessels, and lymphatic tissue without damaging the remaining tissue. Retention of fat (serosa and submucosa) and subsequent rancidity are constant problems in the processing of beef casings. This problem



a *b* *c*

FIGURE 13–9.

Large intestine and examples of the casing quality that are obtainable. (*a*) A transverse sector of the middle portion of hog large intestine, showing its structural pattern: (A) mucosa, (B) submucosa, (C) circular muscles, (D) longitudinal muscles, and (E) serosa. A large amount of fat is concentrated in the submucosa; consequently, the amount of collagenous fibers in this layer is relatively small, e.g., definitely less than in the submucosa of small intestine shown in Figure 13–7*a*, × 63. (*b*) Middle, casing derived after successful sliming from such structure as that shown in (*a*). It also consists of connective tissue fibers of the submucosa (B) plus some undesirable structural elements such as blood vessels and fat. The latter inclusions together with their less substantial amounts of collagenous fibers are responsible for the relative inferior quality as compared with the round shown in Figure 13–8*a*, × 63. (Wang, 1955.) (*c*) A case of unsuccessful, or undersliming, of hog large intestine, showing that both the mucosa (A) and submucosa (B) are left over after the sliming. The presence of blood vessels, torn collagenous fibers (holes), and fat depots among the collagen fibers of the submucosa indicates a low quality of casing as compared with that shown in Figure 13–8*a*, × 63.

is less critical with hog casings, probably because both surfaces of the submucosa are exposed by processing, which would certainly facilitate removal of any submucosa fat.

Defective processing frequently may be observed. In Figure 13–9*a* the middle portion of hog large intestine shows a large amount of fat in the submucosa. Comparison of Figure 13–9*b* and 13–9*c* with Figure 13–8*a* demonstrates the result of inefficient sliming.

Pre-Curing Operations

The intestines of slaughtered animals are carefully removed without punctures to avoid contamination of the carcass as well as to meet the minimum length requirements for casings. There are essentially three operations to be performed prior to curing and grading. These are *removal of fat and mesentery, cleaning and stripping,* and *sliming.*

There are varying amounts of fat associated with the mesentery and its attachment to the gut that must be removed as completely as possible both for their value and because fatty residues become rancid and render stored casings undesirable for use with sausage and other products. This is a manual knife operation and is termed *running*. In this operation the worker also divides the casing into sections, the lengths depending on later use. *Fat removal* is not complete at this point, but after being stripped of their contents, the sections are passed through a series of brushes, which take off the closely adhering fat.

Intestinal contents are *stripped* by machine or by hand under a spray of warm water which washes away the contents as they are expressed and keeps the exterior clean.

The actual technique of *sliming* or removal of mucosa varies with the size and origin of the casing. The small rounds of hog and sheep intestine are first crushed between rollers, then passed between successive rollers or strippers which remove not only the mucosa but also both muscle layers and the serosa leaving only the collagen-rich submucosa. Larger sections, including all the beef sections, are turned inside out, passed through crushing rollers, and then passed between rice-root brushes, then bristle brushes, under a hot spray of water. Beef casings contain considerably greater amounts of smooth muscle than do pork casings; in the latter, only the mucosa and outer coating of the serosa are removed by sliming. The washed and slimed casings are usually stored overnight in cold, 15–20% saturated salt solution prior to grading and curing.

Grading and Curing

Casings are graded according to type, size, and quality (i.e., presence of warts, scars, perforations, and other flaws). Size is determined by inflating the casings with water and measuring the diameter. After being sorted according to size, they are rubbed with medium-fine salt and placed in a tub for one week to cure and drain. Finally, they are shaken out, rubbed with fine salt, and packed in salt in tightly closed barrels. The cured casings contain approximately 40% salt and are sold on this basis. Analysis is necessary since some casings will contain up to 60% sodium chloride.

Challenge for the Future

The utilization of packing house by-products has met with growing competition from substitute materials produced by the chemical industries. Soap, one of the principal markets for animal fats, was replaced by synthetic detergents. Although research has led to the development of new markets that utilize appreciable quantities of fats, the growing supply continues to exert

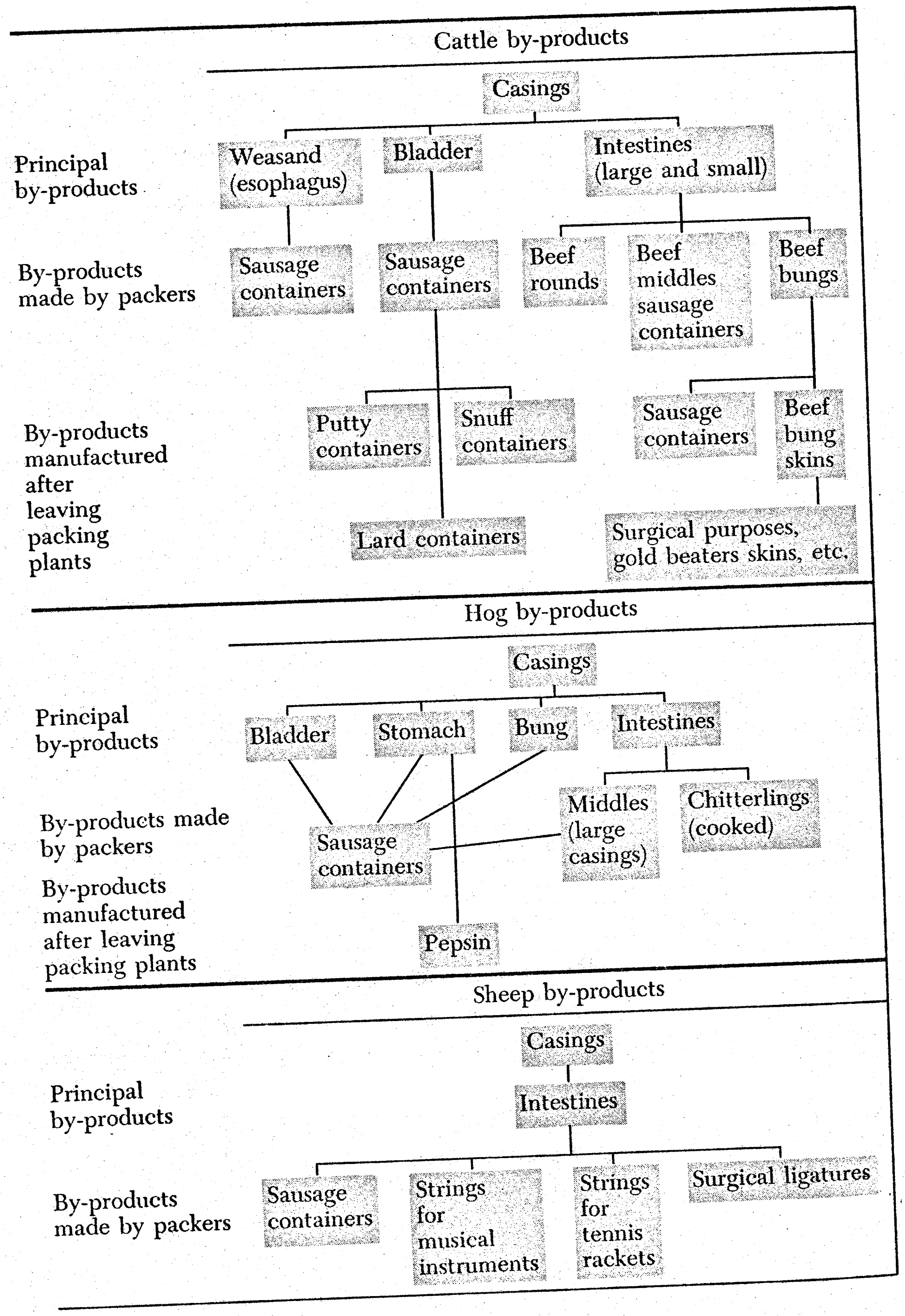


FIGURE 13–10.
Casings products obtained from cattle, hogs, and sheep. (American Meat Institute, 1950.)

increasing pressures on the economy. Similarly there have been serious inroads into the market for collagenous products. Leather, the principal market for hides, has had many improvements in properties and serviceability as a result of research. However, this may not be sufficient to stem the tide of substitution. The newly developed poromerics are now threatening the market for shoe uppers. There is no question that the economic position of hides could be improved through the development of new products. Research on the dispersion and reaggregation of the collagenous tissue has led to the development of reconstituted casings from hide collagen. Research effort on the development of nonconventional markets through the application of newer findings about the structure and behavior of collagen should be continued. The prospects of utilizing the unique fibrous character of collagen in the development of products with new properties useful for incorporation in foods are most intriguing. This concept should also present a challenge to modern science and technology to upgrade much of the other by-product proteins that are permitted to be degraded to nonedibility.

MISCELLANEOUS BY-PRODUCTS

James B. Lesh

A wide range of human ailments is benefited, if not cured, by the administration, under capable medical direction, of properly prepared pharmaceuticals derived from products of the meat packing industry. For centuries meat animals have supplied nutritious foods and valuable nonfood products, but it has been only in comparatively recent years that scientists have learned that chemical substances found in animals have value in treating human ills. By extracting and purifying these substances, the modern pharmaceutical industry has made available an extensive array of medicinal preparations that are useful in treating many diseases of both humans and animals.

Although many centuries passed before man learned the value of certain glands and other tissues extracted from animals, three conditions had to be satisfied before widespread utilization of meat animal material for medicinal purposes could be accomplished. First, an adequate and steady supply of material had to be assured; second, a means of preserving the material was needed; and, third, a vast amount of research and testing had to be done before the specific value of the products became known and they could be used for the treatment of specific diseases. As more has become known about the properties of some of these products, their use has spread into the field of veterinary medicine and, in some cases, into industrial uses.

In most cases, the active principle in a gland amounts to only a minute fraction of the whole; therefore it is necessary to gather large numbers of glands for processing. The meat packing industry became large enough during